

REMARKS

Claims 1-6, 12, 13 and 18-26 are pending in this application. By this Amendment, claims 1, 2, 4 and 5 are amended to address the rejections under 35 U.S.C. §112, first paragraph, and claims 23-26 are added.

No new matter is added by this Amendment. Support for the first step being conducted at the temperature range of 300°C to 650°C may be found throughout the original specification. For example, the specification describes that the first step in each of claims 1, 2, 4 and 5 may be conducted in the range of 300°C to 700°C (see, for example, page 14, line 1, page 17, lines 10-11, page 18, lines 15-22 and page 19, lines 8-9), and further describes specific examples where the first step is conducted at a temperature of 650°C (see, for example, page 20, line 26 to page 21, line 3, Figure 5, page 21, lines 5-9 and page 21, lines 17-21). In view of this, it is clear that the present specification conveyed support for claiming a temperature range for first step of 300°C to 650°C. In this regard, the Patent Office is directed to *In re Wertheim*, 541 F.2d 257 (CCPA 1976) and the discussion of this decision in MPEP §2163.05.III, confirming that the descriptions in the present specification should be found sufficient to provide support for claiming the temperature range of the first step as 300°C to 650°C.

Reconsideration of the application is respectfully requested.

Applicants appreciate the courtesies shown to Applicants' representative by Examiner Song in the June 6, 2008 interview. Applicants' separate record of the substance of the interview is incorporated into the following remarks.

I. Rejection Under 35 U.S.C. §112, First Paragraph

Claims 1-6, 12, 13 and 18-22 were rejected under 35 U.S.C. §112, first paragraph as allegedly not being enabled by the specification. The Patent Office alleged that the specification enabled reacting a solid Al-containing material with a halogenated hydrogen at a

temperature of 300°C to 700°C, but did not enable reacting an Al-containing material with a halogenated hydrogen at a temperature of "700°C or below."

By this Amendment, claims 1, 2, 4 and 5 are each amended to recite that the temperature is from 300°C to 650°C, which is described in the original specification as detailed above. Accordingly, the rejection is believed moot.

Withdrawal of the rejection under 35 U.S.C. §112, first paragraph is respectfully requested.

II. Rejections Under 35 U.S.C. §103(a)

Present claims 1 and 4 are directed to a method for growing an Al-containing III-V group compound semiconductor by vapor phase epitaxy in a reaction chamber made at least of quartz material, wherein a first step in the method comprises reacting a solid Al with a halogenated hydrogen at a temperature of from 300°C to 650°C to produce a halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber. Claims 2 and 5 are directed to a method for growing an Al-containing III-V group compound semiconductor by vapor phase epitaxy in a reaction chamber made at least of quartz material, wherein a first step in the method comprises reacting a solid mixture of group III metals including Al with a halogenated hydrogen at a temperature of from 300°C to 650°C to produce a halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber.

A. Nikolaev In View Of Benander

Claims 1, 3, 18 and 19 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent No. 6,218,269 (Nikolaev) in view of U.S. Patent No. 4,698,244 (Benander). This rejection is respectfully traversed.

Nikolaev and Benander fail to describe or render obvious this recited first step of the method of claim 1.

Nikolaev describes a process for producing pn junctions and p-i-n junctions from group III nitride compound semiconductor materials. The process comprises growing pn junctions and p-i-n junctions by hydride vapor phase epitaxy employing hydride of nitrogen (ammonia, hydrozine) as a source of nitrogen and halides of group III metal as a source of metal. Mg is used as acceptor impurity to form p-type III-V nitride layers. The preferred sources for Ga and Al are Ga and Al metals, respectively. The process is carried out in the temperature range from 900 to 1200°C. See the Abstract. At col. 7, line 64 to col. 8, line 7, Nikolaev describes that:

Then the substrates were heated in Ar flow up to growth temperature and the metals were heated up to temperatures ranged from 350 to 800°C. HCl gas (tank of HCl gas was used for HCl supply) was introduced in the source zone (in Ga channel in case of GaN growth, and in both Al and Ga channels in case of AlGaN alloy growth). As a result of reaction between HCl and Ga (Al), gallium chloride (aluminum trichloride) was formed and delivered to the growth zone by Ar flow.

Although Nikolaev here describes a temperature of 350 to 800°C, Nikolaev does not describe or render obvious reacting a solid Al with a halogenated hydrogen at a temperature of from 300°C to 650°C to produce a halogenated product of Al in a reaction chamber comprised at least of quartz material. Nikolaev fails to describe the unexpected advantages associated with this reaction temperature in a reaction chamber comprised at least of quartz material. The evidence of unexpected results has been discussed throughout prosecution, and is further discussed below.

In the Final Rejection, the Patent Office dismissed the evidence of unexpected results as allegedly not being commensurate in scope with the claims. For example, the Patent Office alleged that the Declaration evidence was not sufficient because the representative

examples for the claimed methods conducted the first step at 650°C instead of 700°C. In view of the amendments to claim 1 discussed above amending the temperature of the first step to be from 300°C to 650°C, this allegation is moot. The evidence representative of the claimed methods is clearly commensurate in scope with the present claims.

For example, the data from the experiments in the Rule 132 Declaration demonstrates the unexpected results achieved in reacting a solid Al with a halogenated hydrogen at a temperature of 300°C to 650°C in a first reaction zone of the reaction chamber, which is made solely of quartz, during the first step of the reaction. By reacting a solid Al with a halogenated hydrogen at a temperature of no more than 650°C in the first reaction zone, an Al component such as AlCl₃ formed in the first reaction zone is transported into the second reaction zone and prevents the quartz reaction tube of the second reaction zone from being corroded, damaged or discolored by the Al component therein.

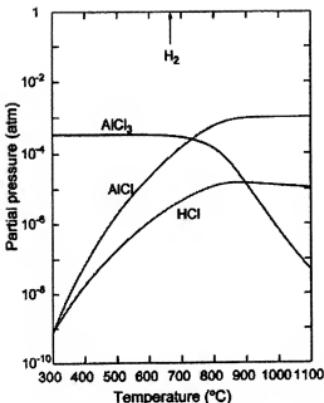
Graphs 1 and 2 in the Rule 132 Declaration illustrate SIMS depth profiles of the AlN layer for the examples disclosed in FIGS. 4 and 5 of the present application. As set forth in the present application, the temperature of the Al material area (first reaction zone of the reaction chamber) of the comparative example disclosed in FIG. 4 was set to 850°C and AlCl gas formed in Al material area was transported from the Al material area into the crystallization area (second reaction zone of the reaction chamber). In the example disclosed in FIG. 5 of the present application, the temperature of the Al material area (first reaction zone of the reaction chamber) was set to 650°C and substantially no AlCl gas was generated.

By comparing the SIMS depth profiles of the AlN layer of the second reaction zone for the comparative example and example of FIGS. 4 and 5, respectively, of the present application as set forth in Graphs 1 and 2, the intensity of [C] and [O] in the AlN layer are substantially the same as or similar to each other. However, the intensity of [Si] for the

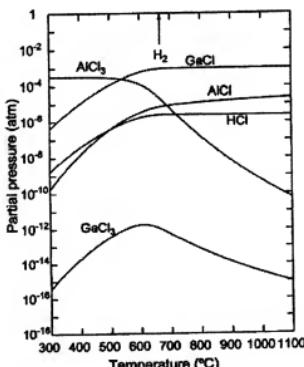
comparative example disclosed in FIG. 4 of the present application (temperature of Al material area set to 850°C) as shown in Graph 1 is over 100 times higher than the intensity of [Si] for the example disclosed in FIG. 5 of the present application (temperature of Al material area set to 650°C). This high intensity of [Si] for the example disclosed in FIG. 5 is caused by deoxidizing and corroding of the quartz reaction tube by AlCl gas, the Al component, present at the second reaction zone. As a result of the reacting the solid Al with a halogenated hydrogen at a temperature of 850°C (example of FIG. 4 of the present application) in a first reaction zone, the quartz reaction tube at the second reaction zone is deoxidized and corroded by the Al gas and Si is emitted.

Thus, the results illustrated in the Rule 132 Declaration demonstrate that reacting a solid Al with a halogenated hydrogen at a temperature of no more than 650°C in a first reaction zone of the reaction chamber produces an Al component such as AlCl₃ for transporting into the second reaction zone that unexpectedly prevents the quartz reaction tube of the second reaction zone from being corroded, damaged or discolored by the Al component therein, and that accordingly results in a superior semiconductor product.

FIGs. 1 and 2 of the present application further support the evidence of unexpected results in the Rule 132 Declaration associated with reacting a solid Al-containing material with a halogenated hydrogen at a temperature of 300°C to 650°C to produce a halogenated product of Al. Specifically, FIG. 1 illustrates that generation of AlCl, which reacts with the reaction tube made of at least quartz, is suppressed and the generation of AlCl₃, which does not react with the quartz of the reaction tube, is predominant at temperatures of 650°C and below:



As evident from FIG. 1, at temperatures of 650°C or less, the production of aluminum monochloride (AlCl) is much less than the production of aluminum trichloride (AlCl_3), which results in the disadvantageous results (corrosion, damage and discoloration of the quartz reaction chamber, and an end crystal including Si contamination and having poorer crystallinity). Similar results are illustrated in FIG. 2 for AlCl and AlCl_3 where the solid includes Al and Ga together:



In the case depicted in FIG. 2, halogenated products of Ga are also formed, and generation of GaCl dominates that of GaCl₃ over the entire temperature range. However, neither of the halogenated products of Ga (GaCl and GaCl₃) is reactive with the quartz reaction tube, and thus does not pose any problems.

The evidence as a whole is thus clearly commensurate in scope with the 300°C to 650°C temperature range recited in claim 1, and demonstrates the unexpected result of suppressing the production of AlCl, reactive with the quartz reaction chamber, in the first reaction step.

During the interview, the Patent Office acknowledged that FIGs. 1 and 2 did show that AlCl becomes predominant at temperatures greater above 650°C, but asserted that FIGs. 1 and 2 are merely partial pressure vs. temperature diagrams that could have been easily prepared by one of ordinary skill in the art from known property data for each of the materials. The Patent Office thus alleged that this evidence could not establish unexpected results associated with the reaction being run at 300°C to 650°C. Applicants disagree. As discussed above, FIGs. 1 and 2 clearly show the effect that achieves the unexpected results, i.e., predominant production of AlCl₃ over AlCl in the range of 300°C to 650°C, and the characterization of the diagrams by the Patent Office is not relevant to the analysis. Applicants found the unexpected results associated with conducting the first step of the claim 1 process at 300°C to 650°C, which is not recognized in the cited art. That is, Nikolaev describes conducting a process at 350°C to 800°C, and nowhere recognizes the unexpected results associated with limiting the temperature range to 300°C to 650°C.

The significance of limiting the temperature of the first step of claim 1 to 650°C at most is further evidenced by the fact that aluminum has a melting point of about 660.4°C. As a result, if the first reaction is conducted at temperatures above 660.4°C, the reaction between

the aluminum and the halogenated hydrogen would be activated only at the lesser surface of aluminum liquid, resulting in a low reaction rate. By maintaining the temperature of the first reaction at 650°C or less, the aluminum is able to remain solid, providing a larger surface and a more effective activation for the reaction to proceed at a more rapid rate. The cited art also fails to recognize this additional significant aspect associated with conducting the temperature of the first reaction at 300°C to 650°C, and thus fails to describe the process of claim 1, or the unexpected results associated therewith, for this additional reason.

Benander was cited as allegedly conducting a reaction of aluminum and hydrogen chloride at 500°C. While such a temperature is identified in Example 1 therein, Benander is otherwise not applicable to the method of claim 1 or the method of Nikolaev. For example, Benander describes a process for making titanium aluminide (TiAl), not a Group III-V compound. Further, the reaction referenced in Example 1 of Benander takes place in a pot 39 (see Figure 1), not indicated to be quartz. Benander describes no concern for the production of AlCl with respect to the use of a quartz reaction chamber, nor describes any advantages to avoiding the production of AlCl by always maintaining a reaction step between a solid Al-containing compound and a halogenated hydrogen at 300°C to 650°C as in claim 1. In fact, the Abstract of Benander indicates that AlCl is desirably produced and used in the formation of the titanium chloride, this indicating a desire for AlCl to be produced.

Benander does not remedy the deficiencies of Nikolaev, and does not describe any advantages associated with a reaction temperature of 300°C to 650°C in a quartz reaction chamber.

Thus, neither Nikolaev nor Benander describes maintaining a reaction step between a solid Al-containing compound and a halogenated hydrogen at 300°C to 650°C as in claim 1, nor describes the unexpected advantages associated with the use of this temperature range in a

quartz reaction chamber. As such, it is clear that neither Nikolaev nor Benander provides any reason or rationale for one to have derived the method of claim 1.

For all the foregoing reasons, withdrawal of this rejection is respectfully requested.

B. Nikolaev In View Of Benander And Further In View Of Shibata And Vaudo

Claims 4, 6 and 21 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nikolaev in view of Benander and further in view of EP 184488 (Shibata) and U.S. Patent No. 6,533,874 (Vaudo). The rejection is respectfully traversed.

As discussed above with respect to claim 1, Nikolaev and Benander fail to describe the recited first step of reacting a solid Al with a halogenated hydrogen at a temperature of 300°C to 650°C to produce a halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber which is made of at least quartz.

Shibata was cited as allegedly describing the use of a carrier gas for HCl.

Vaudo at best teaches that a composition of the (Ga, Al, In)N is controlled by the flow of HCl over each metal as well as by the substrate temperature and by the temperature of each metal.

Neither Shibata nor Vaudo remedy the deficiencies of Nikolaev and Benander detailed above. Like Nikolaev and Benander, Shibata and Vaudo also fail to describe a method for producing an Al-containing III-V group compound semiconductor in a reaction chamber made at least of quartz material by repeating a vapor phase epitaxial growth process to deposit layers of III-V group compound semiconductors of different compositions containing Al as a group III element, wherein the method includes a first step of reacting a solid Al with a halogenated hydrogen at a temperature of 300°C to 650°C to produce a halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber as defined in claim 4, or the unexpected results associated with the recited reaction temperature. Thus,

none of Nikolaev, Benander, Shibata and Vaudo, taken singly or in combination, provide any reason or rationale to have derived the method of claim 4.

For at least these reasons, withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

C. Nikolaev In View Of Benander And Further In View Of Solomon

Claims 2, 12 and 20 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nikolaev in view of Benander and further in view of WO 00/68470 (Solomon). The rejection is respectfully traversed.

As discussed above, Nikolaev and Benander fail to describe the recited first step of reacting a solid Al-containing material with a halogenated hydrogen at a temperature of 300°C to 650°C to produce an halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber which is made of at least quartz.

Solomon merely describes that first and second reagent gas components react in a reactor to form a p-type nitride layer which is deposited on a substrate (see page 13, lines 18-21 of Solomon). Further, Solomon describes that after growth of the layer as a relatively thick film, the layer may be removed from the substrate to provide a p-GaN substrate.

Solomon thus does not remedy the deficiencies of Nikolaev and Benander because Solomon also fails to describe a method for growing a crystal of an Al-containing III-V group compound semiconductor containing Al as a group III element by vapor phase epitaxy in a reaction chamber made at least of quartz material that includes a first step of reacting a solid mixture of group III metals including Al with a halogenated hydrogen at a temperature of 300°C to 650°C to produce a halogenated product of group III, wherein the first step occurs in a first reaction zone of the reaction chamber, as recited in claim 2, or the unexpected results associated with conducting the first step at such reaction temperature. Thus, Nikolaev,

Benander and Solomon, taken singly or in combination, fail to provide any reason or rationale to have derived the method of claim 2.

For at least these reasons, withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

D. Nikolaev In View Of Benander And Further In View Of Solomon, Shibata And Vaudo

Claims 5, 13 and 22 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Nikolaev in view of Benander and further in view of Solomon, Shibata and Vaudo. The rejection is respectfully traversed.

As discussed above with respect to claims 1, 2 and 4, Nikolaev and Benander fail to teach the recited first step of reacting a solid Al-containing material with a halogenated hydrogen at a temperature of 300°C to 650°C or below to produce an halogenated product of Al, wherein the first step occurs in a first reaction zone of the reaction chamber which is made of at least quartz.

None of Solomon, Shibata and Vaudo remedy the deficiencies of Nikolaev and Benander. Thus, the references, taken singly or in combination, provide no reason or rationale to have led one to have derived the method of claim 5.

For at least these reasons, claims 5, 13 and 22 are patentable over all the applied references. Thus, withdrawal of the rejection under 35 U.S.C. §103(a) is respectfully requested.

III. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 1-6, 12, 13 and 18-26 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

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